RHIC RETREAT CLOSE OUT

POWER SUPPLIES AND RAMPING

G.L. Ganetis 10/1/99

- Power Supply, Quench Protection, and Quench Detection
- Ramping and Sequencing Software
- Power Supply Contols

Power Supply, Quench Protection, and Quench Detection Action Items

Uni-polar Insertion P.S.

- DCCT data valid signal is to be interlocked.
- Modify p.s. voltage loop card and SCR firing board to reduce booster interaction.
- Clean and test off switches on the front panel board of the p.s. control card. Replace any switches as needed.
- Test and replace all defective relays on the current regulator cards.
- Continue failure analysis of SCR firing board.

Main P.S.

- Install transorbs across all SCR on all power modules.
- Replace blown SCRs in yellow ramp power module and re-connect the output cables.
- Using test load, modify DSP code to improve transitions between ramp and flat-top power modules.
- Booster interaction needs to be minimized This can only be done when powering the cold ring.
- Finish PLC software for complete remote operations of the main p.s..
- On all main quench protection SCR switches install reverse voltage clamps.

Power Supply, Quench Protection, and Quench Detection Action Items

50 A P.S.

- Clean and test off switches on the front panel board. Replace any switches as needed.
- Change PLC software to prevent p.s. going to off state when FEC gets re-booted.
- Modification of early version of p.s. may be needed to prevent noise from triggering over-voltage crowbar.
- Finish installation of high order correctors and repair all broken p.s.

Sextupole P.S.

- Find temp. sensitivity of the DCCT card.
- Finalize DAC resolution and determine who will design and build cards.

Quench Protection Assemblies

- Replace fan interlock switches on all units.
- Modify IGBT driver board to correct false over-current faults and high pot problem.
- Micro-controller needs software change to fix error found in state diagram.
- Replace the crowbar resistor on Models RQP-10 and RQP-9 . This will prevent too high a current from going through the crowbar SCRs.

Power Supply, Quench Protection, and Quench Detection Action Items

Quench Detection

- Investigate temp. compensation system on all quench detectors. It is not working well for large temp. changes.
- Configure warm-up mode to monitor ground current of the .1 Amp. p.s. used for monitor resistances of magnet coils.
- Implement better filter for RTDL glitches. These still can cause the system to crash.

Major Tasks Still To Be Done

- Installation and test of bi-polar p.s.
- Construction and installation of the gamma-t jump p.s.
- Test of DX quench heater p.s.
- Implement cryo-data transfers
- Operation of p.s. system at high ramp rates and at high currents

Ramping and Sequencing Software
Action Items

Ramping Software

- Initialization – It required too much operator intervention to make sure all WFG were properly initialized. A less skilled operator some times missed required steps. The ramp or magnet mangers will have to monitor this and or alarms will have to be made that will let an operator know when some thing is not properly initialized or have the correct firmware version.

- Loading ramps – It seemed very complex to load different ramps. During p.s. test run loading different levels was most cumbersome. Ramp manager will need improvements.

- Operator controls – Many times a wrong button was clicked on the manger that caused the ramp to crash the p.s. system. The manager will have to keep track of what operation is being done and don't allow any out of sequence.

- Rounding Errors – This will have to be investigated.

- Ramp Testing – It was difficult to confirm if the output of the WFGs were correct. A more efficient way to confirm all WFG are putting out the correct waveform is required. This must be done before any power supply is controlled by it. Wire up information has to be included in the WFG readbacks.

- Diagnostic features – Need capability for ramping a single p.s. at a time. More error messages are needed to get reasons for failures in the managers and ADOs.

- Other things to do – Download sequence of ramps, live ramps, RF control and Gamma t control.

Ramping and Sequencing Software
Action Items

Sequencing Software

- Improve GUI – Display of the time line.
- WFG manger – Smoother integration, Multiple ramps in one " store ".
- Exception handling – Need to define what state to return to after failure.
- Integration with data acquisition – Have to be able to take orbit data at specific stepstones.

Power Supply Controls Action Items

- WFG glitch – Improve diagnostic tools and error messages in trouble shooting this problem. These tools should be able to be used by non-experts.

- RTDL glitch - – Improve diagnostic tools and error messages in trouble shooting this problem. These tools should be able to be used by non-experts.

- MADC noise and offsets – Some location need improvements. The sextupole signals were very noisy and need the buffer chassis installed.

- PLC controls – Diagnostic tools are required to trouble shoot the intermittent problems where commands are not received by a p.s. and status information is not correct.

- P.s. status reading rate -- This rate need improvement. The rate can be as high as 20 sec. on a pet page.

- Sextupole DAC Resolution – Need to improve this to 16 bits.

Power Supply Reliability

We need to examine how the equipment failed, what the causes were, what was done to fix the problems, and what yet needs to be done.

1. Design Flaws - This includes problems such as the simultaneous shut offs in 1000P causing a transformer failure, driver problems causing contactors to fail in IR power supplies.

2. Heat - The summer run caused intolerable heat levels in the service buildings. Insufficient ventilation caused high heat levels in the alcoves. This caused both failures and instabilities. In a general sense, these are also design flaws.

3. Infant Mortality & Manufacturing Defects - As the weak components fail and are replaced, the more reliable components remain. Similarly, as defects (such as pinched wires, loose connections, and poor solder joints) are located and repaired, the occurrences of failure drop.

4. External Causes - Unexpected setpoints, PLC problems, FECs, & Quench Protection Assemblies.

Ramps

The strengths of the magnets must be synchronized to keep the optics functions constant.

dipole: $\alpha = \frac{L}{\rho} = \frac{e}{pc} B \cdot L$

quadrupole: $\frac{1}{f} = K \cdot L = \frac{e}{pc} \frac{\partial B_x}{\partial y} \cdot L$

main dipole: $B\rho(p) = \frac{pc}{e} = m_0 c^2 \sqrt{\gamma^2 - 1}$

$$I_{dipole} = F_{B\,sat}(B) = F_{B\,sat}\left(\frac{1}{\rho}(p) \cdot B\rho\right)$$

$$I_{quad} = F_{Q\,sat}\left(\frac{\partial B_x}{\partial y}\right) = F_{Q\,sat}\left(K(p) \cdot B\rho\right)$$

RTDL :

$\boxed{B_g = F(t)}$ $\boxed{p = F(t)}$ $\boxed{k_1}$ $\boxed{k_2}$

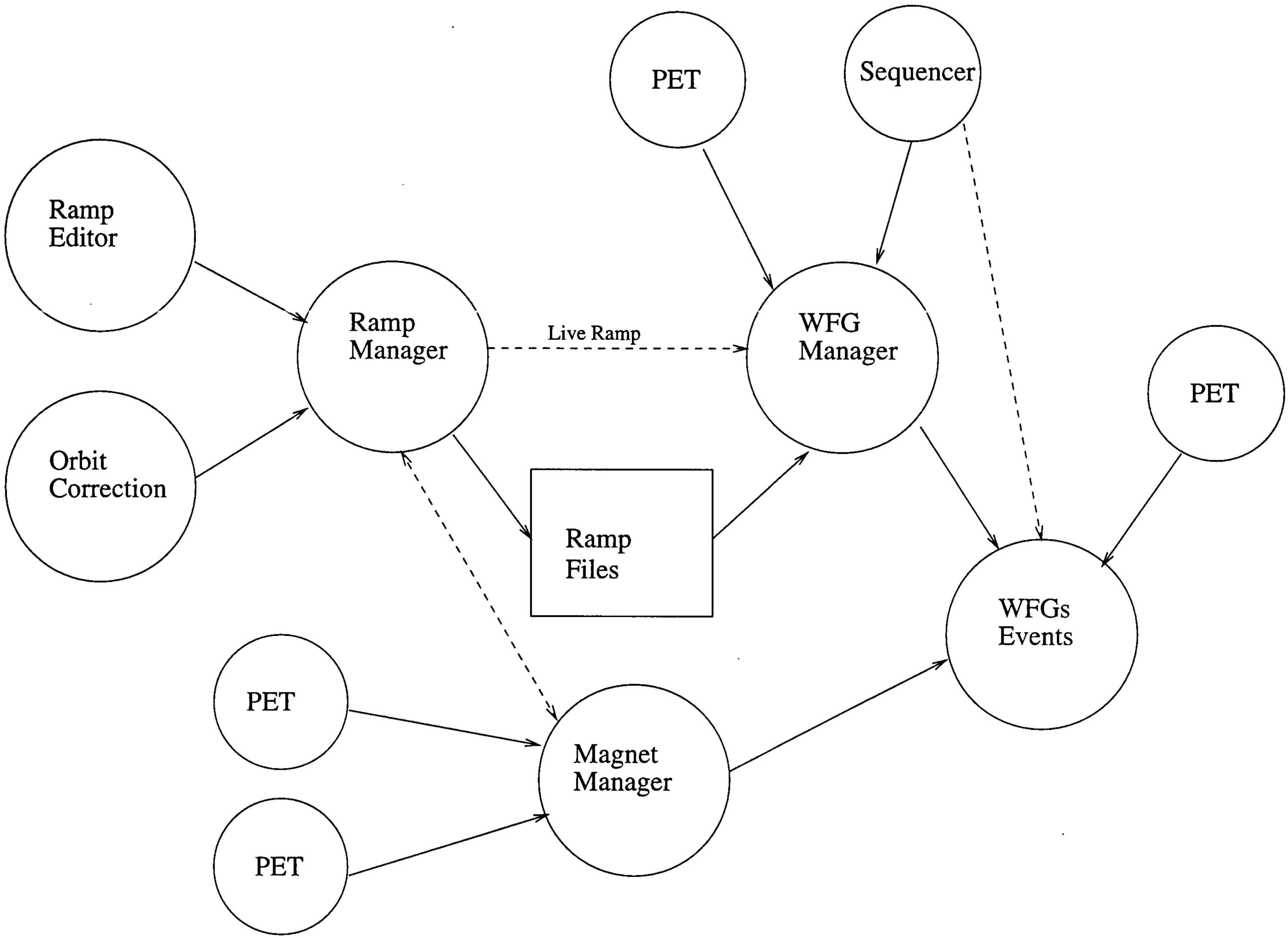
Magnet :

$$K = K_{Trim}(p) + K_{want}(p) + c_1 k_1 + c_2 k_2$$

$$B = K \cdot B_g$$

$$I_{mag} = F(B) \quad \text{(saturation)}$$

$$I_{ps} = I_{mag} - I_{main}$$


PET
Sequencer
Ramp Editor
Ramp Manager
Live Ramp
WFG Manager
PET
Orbit Correction
Ramp Files
WFGs Events
PET
Magnet Manager
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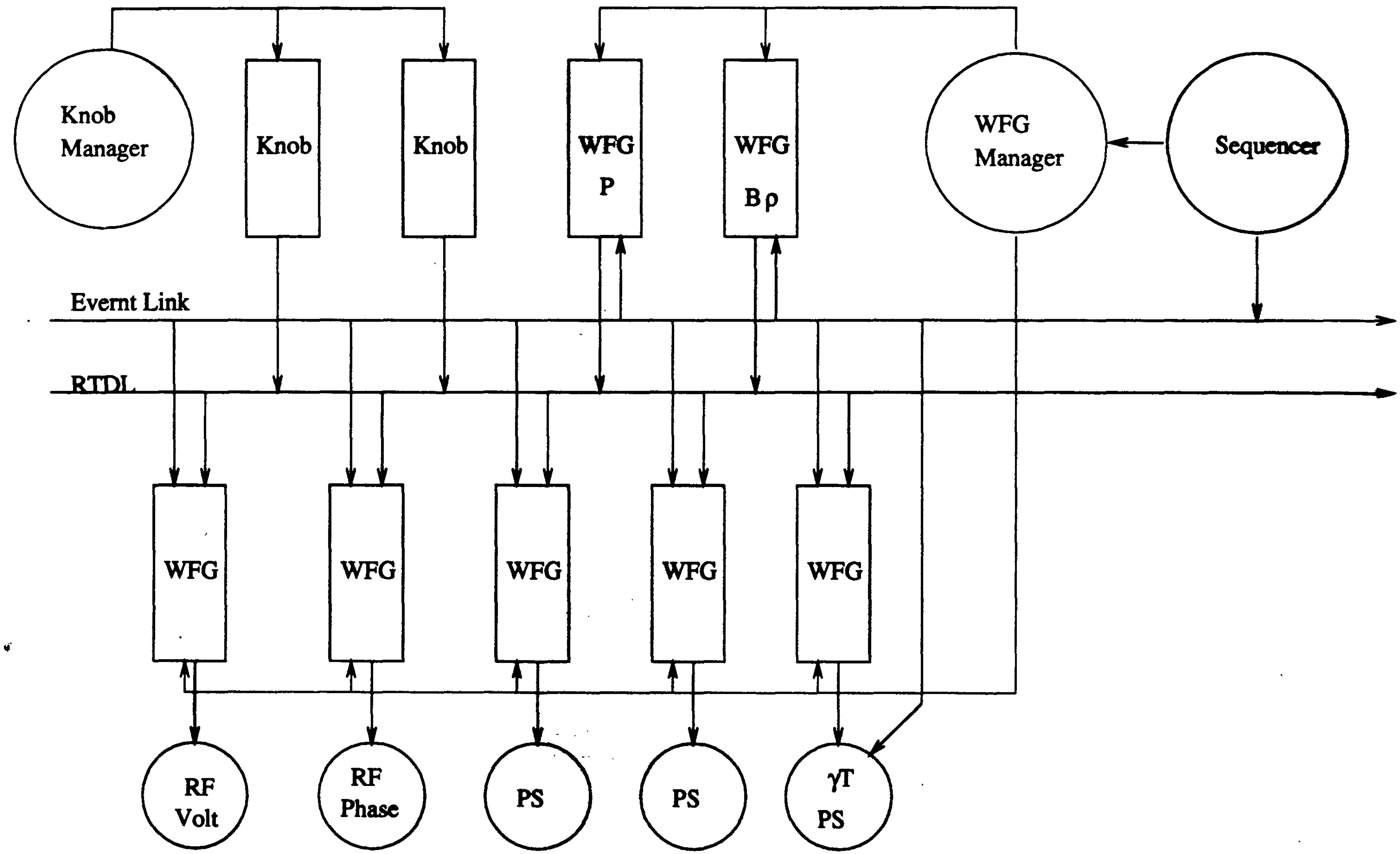

Knob
Manager
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Sequencer
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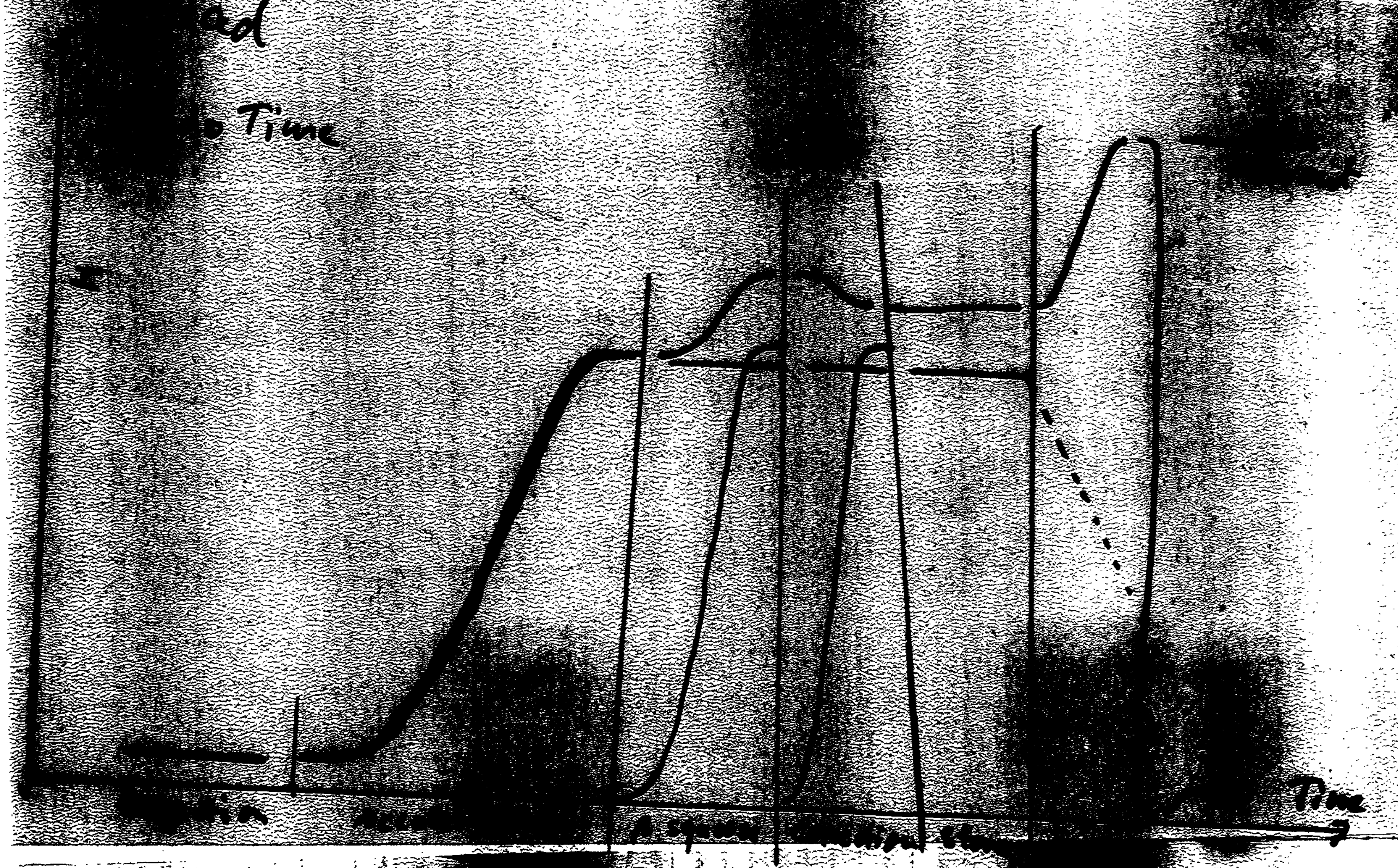
ad
Time
Time

Problems during Operation

WFGs must be initialized

- what: Saturation table
  Park table
  setupTests
  slep limits
- why: reboots
  PET page use
  paranoia
- remedy: monitor system
  alarms
  trust the system

Operator error

- what: push the wrong button
- why: .....
- remedy: inhibit.
  manager must keep
  track of operations

Rounding errors

- to be investigated

Other thing to do

- download sequence of ramps
- alarms
- read backs
- live ramps
- RF control
- γ_t control
- check firmware

Ramps & Sequencing

Johannes van zeijts

RHIC

RHIC retreat, stony brook, 16 september 1999

Issues

- Achievements
- Problems
- Plans for December
- Long term plans

Achievements

- Controlled switching magnet
  - Made easy with help from PS group
- Injected blue & yellow beam
  - Send/monitor events
- Orchestrated 'mini ramps'
  - Talk to WFG manager and 'pseudo-time' WFG

Problems

- Non-expert changes to sequence difficult
  - More an application vs. a general sequencer
- No clean exception handling defined
- Switching magnet
  - Only one set-point saved
  - Switching speed not up to spec.

Plans for December

- Improved GUI
  - Display of time line
- WFG manager
  - Smoother integration
  - Multiple ramps in one 'store'
- Exception handling
  - What state to return to after a problem?
- Integration with data acquisition
  - Take orbit data at specific stepstones

Long Term Plans

- Control/sequence any application
  - Tune meter
  - Profile monitor
  - ...
- Measure and correct AP properties
  - Correct tune / chromaticity

Status of Waveform Generators

and The Future Plans

Al Marusic

The extensive tests in the lab did not uncover any problems with WFGs. Current and future efforts are concentrated on:

- better state and error reporting
- better system integration
- more extensive tests of WFGs in the field
- "glitchless" initialization

The components of WFG system are:

- WFGs (V115, transition module)
- power supply interfaces (PSI)
- power supplies, magnets
- RTDL

The problems encountered during commissioning can be attributed to

- bad RTDL generator (fixed)
- 5 bad transition modules (RTDL receiver, event link receiver)
- 1 bad PSI
- communication problems
- WFG <-> PSI transmission problems in X, Y, U, W lines
- bad WFGs

1. Improved initialization

- change firmware to allow arbitrary first setpoint (currently always 0) and start with the last sent setpoint
  To implement this constant caching of setpoints is needed:
  either 1 sec, 60 Hz or 720 Hz. The efficiency of avoiding glitches depends on the caching rate chosen and the state of the magnet at the time of fec reboot.
- but, the rest of system must recognize this situation and do the rest
  (load tables, make event-formula connections, make proper formula active)
  This is consistent with the caching model accepted for WFGs:
  only high level applications know what the current state of a WFG should be.

2. Error reporting

- three error parameters are introduced
- it will be possible to alarm on them
- high level application should get in habit of examining them (*PSStatus*, ...)
  But to insure more reliable system operations, high level applications should check the state of WFG:
  is the right formula active, is the desired setpoint achieved, ...
- customize ado error messages
- attempt to generate the setpoint outside the limits is now an error

3. Collection of data from WFG

It should be modeled on collection of data from MADC (and follow global model for data acquisition):

- allow writing data to disk
- allow starting and stopping of data logging by ado, stopping of data logging with delay
- these facilities will be used by *PMview*

4. Testing of the whole system

- add code to examine WFG output and input data and report excursions
- simulate running of accelerator (loading formulas into WFGs, sending events, going to park, ramping, etc.) and check error reports
- next phase: put similar code in MADC ado
  That would be end-to-end test of the whole system:
  ramp editor --> WFG manager --> WFG <--> PSI --> PS --> MADC
- special WFG firmware is created for testing RTDL at multiple locations

Summary of Power Supply Test Run

- Operation of all installed p.s. in both blue and yellow ring to a dipole arc current of approx. 2000 Amps. This included all insertion p.s. operating in their nested loops.

- Yellow ring achieved a ramp rate of 6.3 Amps/sec. with only the flat-top p.s. operating. This included all insertion p.s. operating in their nested loops.

- Blue ring achieved a ramp rate of 10.0 Amps/sec. with both ramp and flat-top p.s. operating. This included all insertion p.s. operating in their nested loops. This was done on the last day of testing.

- Found problem with an interaction between the dipole ramp power module and its occ (output circuit compartment). A high voltage transient would develop across the SCRs of the ramp power module when the quench protection switch was opened at low currents. This transient was greater then the reverse voltage rating of the ramp power module's SCRs. This caused six SCRs to fail in the yellow ramp power module.

- Explored methods to reduce booster interaction in the insertion p.s.

- Powered two Quad Trim magnets with bi-polar 150 A p.s. to a level of 90 Amps. This was a complete system test that included controls, quench protection assemblies, and balancing of the quench detector.

- The testing of the DX quench heater p.s. **DID NOT** take place because of a problem that developed in the cryogenic system that caused p.s. testing to stop 10 hours ahead of schedule.

Power Supply, Quench Protection, and Quench Detection Problems

Sextupole P.S.

- DCCT card has a temp. Sensitivity.
- DAC resolution may be to course.

Quench Protection Assemblies

- Fan interlock switches fail open.
- IGBT driver board sometimes gives false over-current faults.
- IGBT driver board has high pot problem.
- Micro-controller needs software change to fix error found in state diagram.
- Models RQP-10 and RQP-9 have too high a current going through its crowbar SCRs.

Quench Detection

- Temp. compensation system not working well for large temp. changes. Also separate problem exists in 1010A with temp. compensation system.
- Warm-up mode ~~has to~~ monitor ground current of the .1 Amp. p.s. used for monitor resistances of magnet coils.
- RTDL glitches still can cause system to crash.

Power Supply, Quench Protection, and Quench Detection Problems

Uni-polar Insertion P.S.

- DCCT data valid signal is not interlocked.
- P.s. powering low inductances have significant booster interaction.
- Off switches on front panel board are failing causing p.s. to go to the off state.
- Defective relay on the current regulator card causes the Iref. signal to fail.

Main P.S.

- Interaction between quench protection switch and ramp power module caused high voltage transient to short SCRs in ramp power module.
- DSP code still needs some work to improve transitions between ramp and flat-top power modules.
- Booster interaction needs to be minimized.

50 A P.S.

- Off switches on front panel board are failing causing p.s. to go to the off state.
- PLC causes p.s. to go to off state when FEC gets re-booted.
- Early version of p.s. need modification to prevent noise from triggering over-voltage crowbar.

Power Supply Controls Problems

- WFG glitch - WFG will go to new value by its self then return to the correct value. Before the proper implementation of the max. excursion factor the Iref would do this in one 720 Hz clock. Now it can take many sec. for this to take place.

- RTDL glitch - This seems fixed on a global level, but I have seen it at one service bldg.. This could be a hardware problem.

- MADC noise – Some location need improvements. The sextupole signals were very noisy.

- PLC controls – There are still intermittent problems where commands sent to a p.s. do not seem to get there. Also when reading the status of a p.s. there are times when they are not correct.

- P.s. status reading rate – This rate can be as high as 20 sec. on a pet page. Use of scripts and how the commands are ordered can minimize the apparent time it takes to read the status.

- WFG initialization – If a FEC had to be re-booted it requires an operator to re-initialize the WFG. Also one has to be able to confirm that this initialization was preformed.

Ramping Software

- Initialization – It required too much operator intervention to make sure all WFG were properly initialized. A less skilled operator some times missed required steps.

- Data base configuration – It seemed very complex to load different ramps. During p.s. test run loading different levels was most cumbersome. (question – who is fred12 and why is he located at gorilla)

- Ramp Testing – It was difficult to confirm if the output of the WFGs were correct. A more efficient way to confirm all WFG are putting out the correct waveform is required. This must be done before any power supply is controlled by it. Wire up information has to be included in the WFG readbacks.

- Operator controls – Many times a wrong button was clicked on the manger that caused the ramp to crash the p.s. system.

- Diagnostic features – Need capability for ramping a signal p.s. at a time.

Major Tasks Still To Be Done

- Installation and test of bi-polar p.s.
- Construction and installation of the gamma-t jump p.s.
- Test of DX quench heater p.s.
- Implement cryo-data transfers
- Operation of p.s. system at high ramp rates and at high currents